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Improving Labour Performance in the Management of Wall Plastering Activity for One Storey Buildings in Abuja, Nigeria

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Abstract

This paper investigated the analysis of labour productivity data of wall plastering work activity from sixty construction sites. The construction work composed of ongoing one story buildings in the study area Abuja metropolis. Data used for the study were obtained using daily method of data collection which has the advantage to capture both quantity and time inputs. A total of 835 observations were made for the wall plastering activity. From these data, the study variables (cumulative productivity, baseline productivity, coefficient of variation and project waste index which is the performance) were computed using conceptual (site-based) model of labour productivity measurement and the results revealed that many of the projects studied had low performance rating while few performed well. A simple regression and correlation analyses were used to determine relationships of the research variables. The result showed that the coefficient of correlation between coefficient of labour productivity variability and performance index was formed to be 0.764 which is significant at 0.01 confidence level. The coefficient of determination (R) was calculated to be 0.67. This showed that 67% variation in crew performance is accounted for by variability in labour productivity. It was recommended that construction project managers should reduce variability by adjusting labour inputs on site.

Key Words; Variability, Labour, Performance, Productivity, Plastering.

1.0 Introduction:

Labour productivity has been identified as an index for measuring efficiency because labour is acknowledged as the most important factor of production since it is one of the major factors that creates value and sets the general level of productivity (Ameh and Odusami, 2002). Enshassi, Mohammed, Mustafa and Mayer (2007) identified labour productivity as the key factor contributing to the inability of many indigenous construction contractors to achieve their project goals which include most importantly, the profit margin amongst others. They suggested the need to investigate and understand the key variables of labour productivity and to keep accurate records of productivity levels across projects.

Andersen and Petterson (1995) suggested the application of benchmarking technique to accelerate change in attitude and behaviour in an organisation. In view of the fact that it is a mechanism for "improvement and change", it will further help an organisation to search for industry best practices that will bring about superior performance by examining the performance and practices of other firms. Therefore to complement government efforts to promote and develop the building industry (Olugboyega, 1995 and Olugboyega, 1998) there is the need to investigate variability in terms of output and input resources for indigenous building firms in Nigeria with a view to increasing performance. In literature the application of modern production concept like reducing variability to increase labour performance in the local industry in Nigeria is very sparse. In this research, with the application of lean technique concept, labour productivity data was obtained from wall plastering activity on a number of projects sites to test relationships between output variability and performance.

Therefore this paper covers review of research components, method of data collection, determination of research variables, analysis of data and discussion, research findings and conclusion.

Review of Research Components

1.1 Performance

The word performance is the umbrella term of excellence and includes profitability and productivity as well as other non-cost factors such as quality, speed, cost, dependability and flexibility. (Tangen, 2005). The performance of any construction firm as an organisation is a function of the individual's performance. This is based on the assumption that the individual effort is tailored towards achieving the company's objectives. "In other words, that's what makes up a development in individual's performance which has a multiplier effect in the firm's general performance" (Grunberg, 2004 and Lema, 1996).

1.2 Profitability

Profitability has been defined as keystone of performance measurement systems with respect to corporate performance (Lema, 1996). But relating to improvement purposes, profitability does not have a direct impact on performance. Profitability is explained as the fruit of the actions and processes in operations. "It helps to identify the effects of monetary effects like inflation, price changes and currency effects and distinguishes them from true performance and productivity change" (Grunberg, 2004).

Profitability therefore can be defined as the ratio between revenue and cost. It is expressed mathematically by (Bernolak, 1997 cited in Grunberg, 2004) as;

$$\frac{Output\ Volume \times Output\ Unit\ Price}{Input\ Volume \times Input\ Unit\ Cost} \quad \text{.... eq 1.1}$$

Tangen (2005) further defined profitability as the ratio between revenue and cost (i.e. profit /assets). This is the overriding goal for the success and growth of any business. Tangen, however cautioned that an increased productivity does not necessarily lead to increased profitability. He suggested that "organizations should combine productivity and profitability ratios so that the true reasons for increased profits become clearer" (Tangen, 2004).

Profitability factor has been identified generally as outcome of what happened in a production process. This factor cannot fully explain what happened in the process in order to form a basis for future actions (Lema, 1996). This is viewed as a limitation by some researchers when financial indicator is employed as performance measurement.

1.3 Performance measurement

Construction jobsite performance can be measured (Alfeld, 1988). Performance measurement in any organisation is based on the assumption that there is a standard against which comparison can be made, this benchmark could be internally and externally based. Performance measurement has been described as the process of quantifying the efficiency and effectiveness of actions. "For a performance measurement system to be regarded as a useful management process it should act as a means that enables assessment to be made, provides useful information and detects problems, allows judgment against certain predetermined criteria to be performed and more importantly, the systems should be reviewed and updated as an ongoing process." (Benon, and Milton, 2010).

Regular assessment of performance in an organization helps management with invaluable information to guide in decision making. The importance of regular performance cannot be overemphasized. The exercise makes management to be competent, transforms average site managers to performers and supplies management with the better information on which right decisions and actions are taken. According to Alfeld, contractors performance has two aspects, firstly accomplishment and secondly, method employed to accomplish the task.

Accomplishment here represents finished work of value to the job while method describes how the work was done for instance, the total member of blocks laid is an accomplishment; the number of labour man hours represents the method. Therefore, performance can be defined as the ratio of accomplishment to methods.

It is also expressed as;

$$Performance = \frac{Accomplishment}{Methods} \quad (1.2)$$

$$Performance = \frac{QTY\ (Value)}{Manhours\ (Cost)} = \frac{Output}{Input} \quad (1.3)$$

The above performance ratio reveals to us that a contractor can raise his competence by increasing the value of accomplishments while reducing the amount of time, energy and money spent on methods. Therefore "worthy performance occurs when the value of the accomplishment exceeds the cost of the method" (Alfeld, 1988). This means that contractors improve on their performance by investing resources in reducing the cost of the labour input (methods) required to accomplish a given tasks. The measurement of accomplishment helps to identify deficiencies in work methods. Construction performance is improved by management if such deficiencies are corrected. The definition of performance here is similar to that of productivity. This is explained by the Triple P model that performance, productivity and profitability can all be expressed as ratios of output and input.

However, performance engineering defines productivity in a narrower context of jobsite labour man hours divided by quantity of work produced which is an important and very useful measurement of jobsite performance. This is a measure of only one performance dimension. Alfeld (1988), suggested that performance measurement should be related to a baseline or exemplar performance. This assertion was corroborated by

Thomas and Zavrski (1999a), 1999b) and Enshassi *et al.* (2007) that performance should be measured in relation to baseline productivity.

Lean concept identifies project management index (PMI) or project waste index as useful tool to measure jobsite performance. According to Thomas and Zavrski (1999a), 1999b) and Abdel Hamid *et al.* (2004), Performance (PMI) is expressed mathematically thus:

$$PMI(Performance) = \frac{Cumulative\ Productivity - Baseline\ Productivity}{Expected\ Baseline\ Productivity} \qquad (1.4)$$

1.4 Project Management Index (PMI): The project management index sometime referred to as project waste index (PWI) is a dimensionless parameter that reflects the influence that project management has on the cumulative labour operations. It is expressed as the ratio of the difference between the cumulative productivity and baseline productivity over expected baseline productivity (Thomas and Zavrski, 1999a), 1999b). According to Abdel – Razek *et al.*, 2007, PMI is a measure of the difference between the actual and baseline productivity, it provides a measure of the impact of poor material, equipment and information flows, and inadequate planning. This makes it a measure of waste, which is one of the issues being addressed by lean construction. Reduced waste can lead to better flow and productivity. The lower the PMI value the better is the project management's influence on overall operation (Thomas and Zavrski, 1999b). Mathematically, the PMI eliminates the productivity influence of complex design.

1.5 Reduce Variability in Labour Productivity: Thomas *et al.* (2002) stated that different strategies for managing construction variability emerge from lean thinking. Some focus on reducing work flow variability with the intention of improving project performance by increasing throughput, while others employ the strategy of capacity management that is, using flexibility in responding to variability which has the capacity to improve operation by permitting rapid changes as needed.

Thomas and Zavrski (1999b) concluded in their study that the variability in daily labour productivity is highly correlated to project performance. Also that variability in productivity appears to be a good determinant of good and poorly performing project. Thus the goal of lean construction as stated by Thomas and Zavrski should be to improve performance by reducing variability in labour productivity. This variability in the daily labour productivity was computed using the developed mathematical equations by Thomas and Zavrski 1999a adopted in Idiake and Bala (2014)

2.0 RESEARCH METHODS

2.1 Collection of Data

The data collection for on-site productivity study was conducted on wall plastering activity. Data collection covers wall plastering activity in 60 live projects from building contractors within the study area (Abuja). Daily visit method of observation of labour productivity was adopted. This involved personal observation of labour activities on the selected work on live projects. The strategy here was to visit the site daily and interact with the foreman and workers in order to record the dates, number of workers, starting time, closing time and measurement of length/breadth of work done (quantities) of each worker. Entries were made on research instrument collection sheet designed for this purpose. The figures collected were analysed using lean benchmarking approach of calculating performance using Thomas *et al* (1990) mathematical model.

2.2 Population of the Study and Sampling Technique

The population of the study was drawn from contractors handling one storey building projects in the study area. The builders were involved in different types of construction activities such as mass housing projects of bungalow category, storey building housing projects and infrastructures. In order to meet the objectives of the study, the research samples were drawn from contractors constructing one storey buildings for the purpose of homogeneity. The research team was able to collect data from sixty (60) construction sites, randomly drawn from the available builders. A total of 835 data points were obtained for all wall plastering activity from these sites. At the time of data gathering, it was observed that most of the firms were executing projects at various stages of completion.

2.3 Data Analysis and Evaluation was conducted using the following statistical tools;

1. Descriptive Statistics
2. Inferential Statistics

(i) Box and Whisker analysis

(ii) Regression analysis

3. Mathematical Model by Thomas *et al* (1990; 1991)

3.0 DATA PRESENTATION AND DISCUSSION OF RESULTS

The test for normality of productivity was found to be slightly normally distributed. A sample size of 377 was computed to be adequate, but a data set of 835 was obtained for the study, this was done to enhance the accuracy level. The mean of the sample was found to be 1.164 whr /m^2 and the median was determined to be 0.990 whr /m^2. It was observed that the mean of the estimate was higher than the median. This indicates that the frequency distribution is not symmetrical. It is a skewed distribution as shown in Figure 1. Also the distribution is positively skewed having a skewness value of 0.645 and standard deviation of 0.440.

The distribution of the sample variable was fairly normally distributed. The measure of variability was determined from the normal probability statistics computed. The range was found to be 1.650 which is the difference between the highest and the lowest data in the distribution. The average coefficient of variation for all the projects which is the product of the standard deviation and the mean was calculated as 37.76%.The labour productivity values obtained were used to compute the cumulative productivity.

The cumulative productivity is a measure of the overall effort required to accomplish a task. It is an important aspect in assessing wall plastering crew performance from project management index perspective. Statistical analysis of data showed that the mean and standard deviation of cumulative productivity were found to be 1.06whr/m^2 and of 0.175 respectively.

3.2 Box and Whisker's Test

The productivity data were tested for any extreme outliers. The box and whiskers technique was adopted to examine the level of possible extreme outliers present in the data. Although extreme outliers were dealt with at pilot study stage, it was observed that the data for the site activity was free from extreme outliers as shown in Figure 1. A graphical observation of the box and whiskers plots for the wall plastering activity points out that the line of symmetry in the box was tilted towards the lower arm. This points toward the fact that the data were not symmetrical therefore which made the data to be either skewed to the right. The plot shows that the data was positively skewed to the right. This finding confirmed the conclusion from other researchers that positive skewness is common to construction activities with occasional negative skewness.

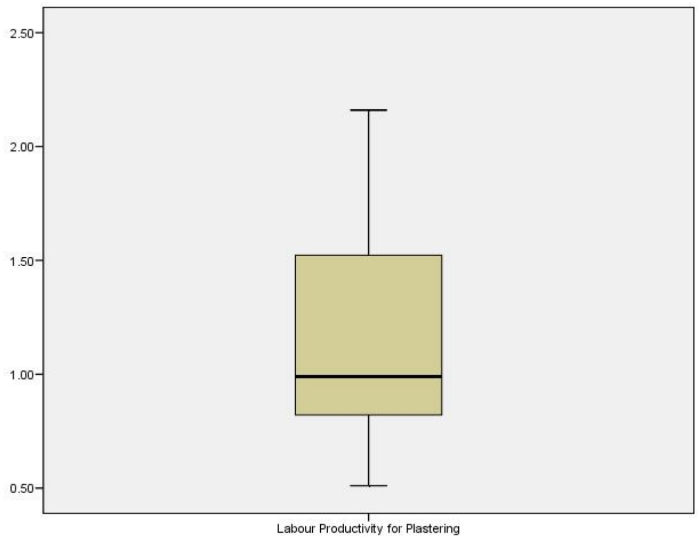

Figure 1 Box and Whisker's Plot for Labour Productivity Data

3.3 VARIABILITY IN DAILY LABOUR PRODUCTIVITY FOR WALL PLASTERING ACTIVITY

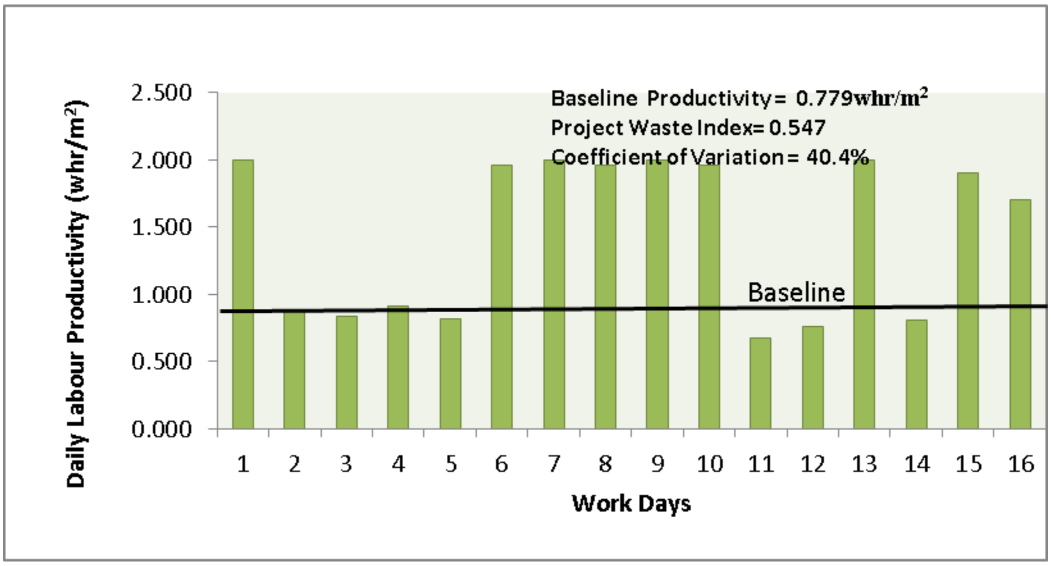

Figure 4 Relationship of daily labour productivity, baseline productivity and performance for wall plastering activity (Project 2)

3.3.1 Wall Plastering Activity: Figure 4 shows the variability in daily labour productivity of wall plastering task for project 2. The variability computation was done for each of the other 60 projects examined see Table 1. It was determined from input and output relationship. The computed values of coefficient of variation for wall plastering activity range from 0.082 to 0.565. This is similar to the computation which is the product of the standard deviation divided by the mean of the estimate.

Sixteen working days were observed for wall plastering activity, the gang size, work hours, daily quantity, daily labour productivity, baseline days and abnormal days. The wall plastering task observed in the project was done for sixteen days. The total gang size employed to construct 1127 square metre of plaster work was 168 men with a total work hours of 1395hrs. This indicates that the construction firm used one site worker to achieve approximately 6.708m^2 of plaster. The daily productivities ranged from 0.675 to 2.00whr/m^2. The wall plastering work has a cumulative productivity of 1.238whr/m^2.This indicates that labour input was low since this cumulative productivity is greater than unity. The following days 3, 5, 11, 12, and 14 were identified as baseline days for concreting task. These are the highest productivity scores that were considered to define the baseline subset and the average of these five figures (0.835, 0.821, 0.675, 0.761 and 0.804whr/m^2) represents the baseline productivity or benchmark for the project which is calculated to be 0.779whr/m^2.

The project waste index which provides a measure of labour performance was found to be 0.547 which is the worst pwi of all 60 projects investigated. This index as earlier mentioned facilitates the comparison of labour performance to a baseline criterion. The higher the pwi figure the poorer the labour performance. Figure 4 showed level of gap between daily labour productivities and the baseline productivity. The coefficient of variation was found to be 40.40%. This level of variation shows that there is ample space for improving labour performance. The wider the values of daily labour productivity from the baseline productivity the poorer the labour performance. Project 56 in Figure 5 for wall plastering activity shows a better performance with daily productivity close to the baseline productivity value. The baseline productivity for the project was computed to be 0.830whr/m^2.

Also it was observed that the gap between the daily productivities and the baseline productivity provided a coefficient of variation of 8.2% which produced a better labour performance (pwi) of 0.115 compared to 0.547 obtained for project 2.

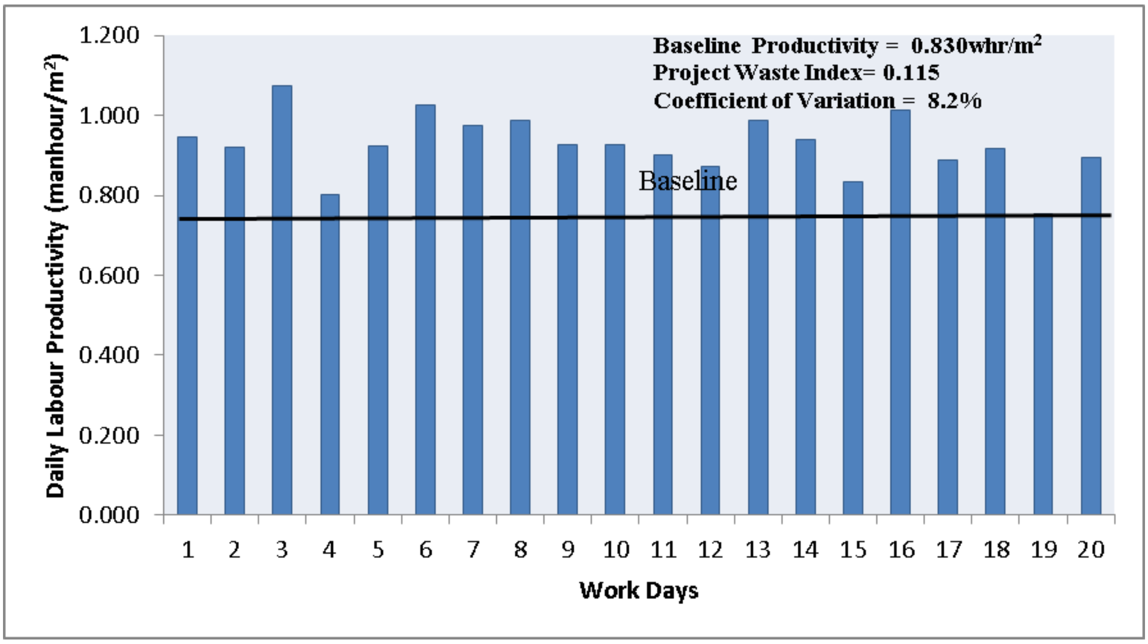

Figure 5 Best relationships of daily labour productivity, baseline productivity and performance for wall plastering activity (Project 56)

3.3.2 Summary: The assessment of variability is achieved by measuring the variations in daily labour productivity rates over the period of the projects. This assessment has been carried out in this section. Considering the results of individual projects for all 60 sites Table 1 for the wall plastering activity investigated, it was observed that the analysis demonstrated variability in daily labour productivity.

The mean variability for wall plastering was found to be 37.76%. These results compete favourably with that of previous studies which were discovered to be 28%.

The level of variations in daily productivities of all sites examined showed ample rooms for labour performance improvement. This means that the extent of gaps between the daily productivities and the baseline productivity were dependent on the level of the coefficient of variability. It was also found out that the closer the values of daily labour productivity to the baseline productivity the better the labour performance this is evidenced with some of the projects that performed well which have low pwi values. Which means reducing variability improves labour performance. Therefore, this supports the lean theory that stipulates that job site labour performance can be improved upon by reducing variability in labour productivity.

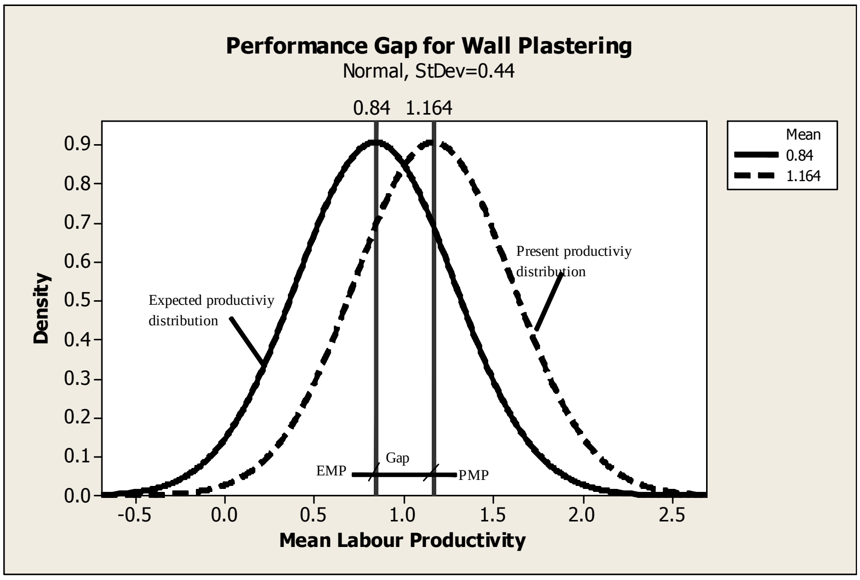

Figure 6 Normal Distribution Plot of Performance Gap for Wall Plastering

3.3.3 Performance Improvement Gap Measurement

The target performance improvement gap of the site activity examined in this study is shown in Figure 6 for wall plastering. The distributions define the productivity variability which provides opportunity for improvement.

The target performance improvement gap, which is as a result of variability is assessed or quantified by determining the difference between expected mean productivity (EMP) (which is the mean baseline productivity) and present mean productivity (PMP). The wider the gap between PMP and EMP the bigger the value of the target performance improvement gap.

The performance improvement gap value for wall plastering is found to be 0.324 man hrs / m^2. The process performance improvement can be achieved by adjusting the group of variables that mainly influence the performance indicator. Therefore reducing these performance gap values could mean a significant improvement in performance, profit and productivity for builders and contractors.

4.0 FINDINGS

(1) Correlation between project waste index (performance) and coefficient of variability for work flow for plastering work = 0.521.

(2) Correlation results show that there is strong association between dependent variables project waste index (performance) and coefficient of variability for labour productivity which is the independent variables. The analysis yielded R value of 0.764. Therefore, the independent variables are thus found to be significant predictors of performance of site labour crew for the activity investigated.

(3) Plastering work showed that the coefficient of variability in labour productivity which is the independent variable as well as the predictor set, could account for 67% of the variability in crew performance in terms of labour productivity.

(4) Labour productivity gaps of 0.324 man hrs / m^2 was observed wall plastering.

5.0 CONCLUSION

This research work investigated the effects of workflow variability and labour productivity variability on the job site performance. Using labour productivity data from wall plastering activity on multiple projects, various parameters of output and input variability were tested against construction performance. The labour workflow productivity data analyzed were found to be slightly skewed. The value of skewness was greater than zero but less than one. This showed the level of reliability of data used in the analysis.

The correlation relationship between work flow variability and performance was found to be moderate for wall plastering activity. Similarly, the correlation between labour productivity and performance was discovered to be highly significant for the selected site activity therefore it is suggested that in measuring the impacts of variability on performance, emphasis should be placed on labour productivity variability instead of work flow or construction output variability. The values of variability in labour productivity were compared with the project performance (PWI) it was found out that the higher the values of labour productivity variability the poorer the

performance. Also the baseline productivities computed for all selected activities were compared with the mean labour productivity.
It was discovered that performance gap exists for wall plastering activity. This is an indication of opportunity for performance improvement in labour utilization for all the sites investigated. The present productivity distribution was higher than the expected productivity distribution, this represents a gap in performance.

6.0 RECOMMENDATIONS

2 The correlation relationship between work flow variability and performance was found to be moderate for wall plastering therefore it is recommended that in measuring the impacts of variability on performance for wall plastering, emphasis should be placed on labour productivity variability instead of work flow or construction output variability.
3 The correlation between labour productivity and performance was discovered to be highly significant for plastering therefore it is suggested that labour productivity variability be used to measure the impacts of variability on performance.
4 The variations in crew performance in the activity investigated was found to be as a result of variations in labour productivity therefore site managers should be determined to get more output with a reduction in labour input.
5 It is proposed that site managers should close up performance gaps in project execution by reducing the disparity in values between baseline productivity and the mean labour productivity for project.

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Appendix 1 Computation of Research Variables

S/N	Project code number	Coefficient of Variation Qty	Coefficient of Variation LP	Average daily output m^3	Cumulative Productivitywhr/m^3	Baseline Productivity	Project waste index
1	Project 1	0.45	0.422	64.30	1.1110	0.8113	0.357
2	Project 2	0.44	0.404	70.44	1.2378	0.7789	0.547
3	Project 3	0.51	0.517	54.18	1.0201	0.6374	0.456
4	Project 4	0.51	0.483	48.93	1.0277	0.6049	0.504
5	Project 5	0.53	0.516	91.58	0.9873	0.6694	0.379
6	Project 6	0.64	0.479	41.88	1.0284	0.6455	0.456
7	Project 7	0.40	0.470	52.50	0.9673	0.7104	0.306
8	Project 8	0.35	0.383	122.46	1.1531	0.8455	0.366
9	Project 9	0.30	0.333	126.79	1.1342	0.8455	0.344
10	Project 10	0.18	0.090	94.74	1.4566	1.3515	0.125
11	Project 11	0.24	0.146	70.60	1.3654	1.2599	0.126
12	Project 12	0.19	0.137	92.33	1.4340	1.3009	0.159
13	Project 13	0.28	0.141	83.87	1.3245	1.1760	0.177
14	Project 14	0.18	0.107	82.02	1.4728	1.3603	0.134
15	Project 15	0.27	0.253	117.87	1.1725	0.9463	0.269
16	Project 16	0.34	0.330	129.80	1.1063	0.8409	0.316
17	Project 17	0.34	0.400	122.61	1.0447	0.8222	0.265
18	Project 18	0.29	0.338	135.73	1.1155	0.8296	0.341
19	Project 19	0.51	0.501	56.00	0.8897	0.5488	0.406
20	Project 20	0.38	0.458	92.08	1.0056	0.7389	0.318
21	Project 21	0.21	0.124	76.43	0.7533	0.6470	0.127
22	Project 22	0.66	0.550	50.61	0.8211	0.6567	0.196
23	Project 23	0.68	0.310	61.00	1.0361	0.7871	0.297
24	Project 24	0.78	0.254	42.98	0.9586	0.7926	0.198
25	Project 25	0.62	0.185	62.62	0.9146	0.8008	0.136
26	Project 26	0.25	0.132	18.15	1.3499	1.2300	0.143
27	Project 27	0.62	0.529	35.17	0.8502	0.6254	0.268
28	Project 28	0.51	0.461	45.82	1.0010	0.6328	0.439
29	Project 29	0.51	0.461	42.14	1.0108	0.6419	0.439
30	Project 30	0.40	0.416	54.33	1.1096	0.7238	0.460
31	Project 31	0.33	0.404	55.05	1.0527	0.7658	0.342
32	Project 32	0.30	0.194	161.65	0.7720	0.6601	0.133
33	Project 33	0.48	0.279	128.10	0.8141	0.6510	0.194
34	Project 34	0.39	0.498	115.82	0.9405	0.6743	0.317
35	Project 35	0.54	0.416	73.73	0.9178	0.7459	0.205
36	Project 36	0.26	0.156	74.41	1.4152	1.2728	0.170
37	Project 37	0.53	0.377	102.60	0.9922	0.8060	0.222
38	Project 38	0.20	0.127	69.83	1.3204	1.1914	0.154
39	Project 39	0.33	0.209	96.17	1.0710	0.9226	0.177
40	Project 40	0.31	0.271	96.81	1.0846	0.8514	0.278
41	Project 41	0.44	0.350	116.55	0.9687	0.7494	0.261
42	Project 42	0.49	0.372	91.73	0.9354	0.7232	0.253
43	Project 43	0.18	0.155	70.92	1.1266	0.9950	0.157
44	Project 44	0.23	0.132	71.83	1.1986	1.0804	0.141
45	Project 45	0.30	0.130	88.83	1.4151	1.2939	0.144
46	Project 46	0.42	0.343	54.80	0.8851	0.7547	0.155
47	Project 47	0.54	0.565	49.83	0.8429	0.5964	0.294
48	Project 48	0.63	0.404	31.13	1.0921	0.7043	0.462
49	Project 49	0.62	0.390	57.57	1.1803	0.7645	0.495
50	Project 50	0.33	0.123	65.80	0.9134	0.7953	0.141
51	Project 51	0.44	0.392	38.00	1.1150	0.7999	0.375
52	Project 52	0.36	0.430	51.10	1.1086	0.7815	0.390
53	Project 53	0.49	0.394	57.16	1.1639	0.8170	0.413
54	Project 54	0.24	0.125	84.82	1.0486	0.9237	0.149
55	Project 55	0.25	0.101	94.77	0.9591	0.8427	0.139
56	Project 56	0.19	0.082	89.40	0.9267	0.8303	0.115
57	Project 57	0.42	0.475	79.53	0.9267	0.7313	0.233
58	Project 58	0.28	0.098	98.51	0.9415	0.8316	0.131
59	Project 59	0.36	0.381	85.55	1.0686	0.8442	0.267
60	Project 60	0.19	0.140	90.21	0.9195	0.7593	0.191